What is claimed is:

1. A method of producing a conjugated diene polymer which comprises polymerizing a conjugated diene compound with a catalyst consisting essentially of the following components (a) to (d) in an organic hydrocarbon solvent; and then reacting with at least one compound selected from the group consisting of the following components (e) to (j).

Component (a): a compound containing a rare earth element of atomic number 57-71 in the Periodic Table or a compound obtained by reacting the compound with a Lewis base;

Component (b): a compound containing at least one halogen atom;

Component (c): an aluminoxane;

Component (d): an organoaluminum compound represented by the following general formula (1):

$$AlR^1R^2R^3 \quad \cdots\cdots (1)$$

(wherein R^1 and R^2 are the same or different and are a hydrocarbon group having a carbon number of 1-10 or a hydrogen atom, and R^3 is a hydrocarbon group having a carbon number of 1-10 provided that R^3 is the same as or different from R^1 or R^2);

Component (e): a halogenated organometallic compound, a halogenated metal compound or an organometallic compound represented by the following general formula (2), (3), (4) or (5):

$R^4_nM'X_{4-n}$, ····· (2)

$M'X_4$, ····· (3)

$M'X_3$ ····· (4)

$R^4_nM'(-R^5-COOR^6)_{4-n}$ ····· (5)

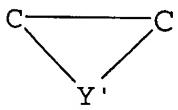
(wherein R^4 and R^5 are the same or different and are a hydrocarbon group having a carbon number of 1-20, R^6 is a hydrocarbon group having a carbon number of 1-20 and may contain an ester group in its side chain, M' is a tin atom, a silicon atom, a germanium atom or a phosphorus atom, X is a halogen atom, and n is an integer of 0-3);

Component (f): a heterocumulene compound having a chemical structure of the following general formula (6):

Y=C=Z ····· (6)

(wherein Y is a carbon atom, an oxygen atom, a nitrogen atom or a sulfur atom, and Z is an oxygen atom, a nitrogen atom or a sulfur atom)

Component (g): a hetero three-membered-ring containing compound having a chemical structure of the following general formula (7):



····· (7)

(wherein Y' is an oxygen atom, a nitrogen atom or a sulfur atom);

Component (h): a halogenated isocyano compound;

Component (i): a carboxylic acid, an acid halide, an ester compound, a carboxylic ester compound or an acid anhydride represented by the following general formula

(8), (9), (10), (11), (12) or (13):

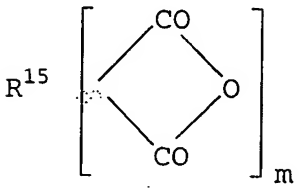
$$R^7-(COOH)_m \quad \cdots\cdots (8)$$

$$R^8-(COX)_m \quad \cdots\cdots (9)$$

$$R^9-(COO-R^{10}) \quad \cdots\cdots (10)$$

$$R^{11}-OCOO-R^{12} \quad \cdots\cdots (11)$$

$$R^{13}-(COOCO-R^{14})_m \quad \cdots\cdots (12)$$



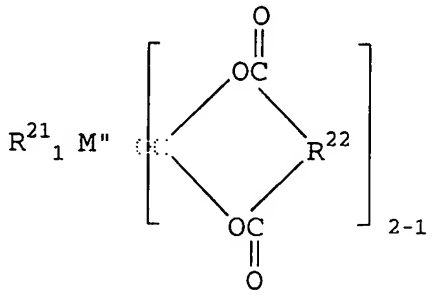
$\cdots\cdots$ (13)

(wherein R^7 to R^{15} are the same or different and are a hydrocarbon group having a carbon number of 1-50, X is a halogen atom and m is an integer of 1-5);

Component (j): a metal salt of a carboxylic acid represented by the following general formula (14), (15) or (16):

$$R^{16}{}_lM''(OCOR^{17})_{4-l}, \quad \cdots\cdots (14)$$

$$R^{18}{}_lM''(OCO-R^{19}-COOR^{20})_{4-l} \quad \cdots\cdots (15)$$



$\cdots\cdots$ (16)

(wherein R^{16} to R^{22} are the same or different and are a hydrocarbon group having a carbon number of 1-20, M" is a tin atom, a silicon atom or a germanium atom, and l is an integer of 0-3).

2. The method according to claim 1, wherein the resulting polymer after the polymerization with the catalyst has a content of cis-1,4-bond of not less than 90% and a ratio of weight-average molecular weight to number-average molecular weight of not more than 3.5 as measured by a gel permeation chromatography.

3. The method according to claim 1, wherein the resulting final polymer has a content of cis-1,4-bond of not less than 90% and a ratio of weight-average molecular weight to number-average molecular weight of not more than 4 as measured by a gel permeation chromatography.

4. The method according to claim 1, wherein the component (a) is selected from the group consisting of a carboxylate, an alkoxide, a β-diketone complex, a phosphate and a phosphite of neodymium, praseodymium, cerium, lanthanum or gadolinium.

5. The method according to claim 1, wherein the component (b) is selected from a metal halide, an organometallic halide, an organic halide compound and a halogenated silicon compound.

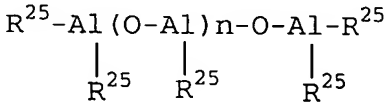
6. The method according to claim 5, wherein said metal halide or organometallic halide is selected from diethylaluminum chloride, ethylaluminum sesquichloride, ethylaluminum dichloride, diethylaluminum bromide, ethylaluminum sesquibromide and ethylaluminum dibromide.

7. The method according to claim 5, wherein said organic halide compound is selected from benzoyl chloride, xylene dichloride, xylene dibromide, propyonyl chloride,

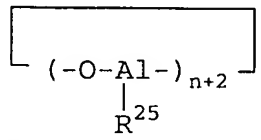
benzyl chloride, benzylidene chloride, t-butyl chloride and the like; organic bromine compounds such as benzoyl bromide, propyonyl bromide, benzyl bromide, benzylidene bromide, t-butyl bromide and the like; methylchloroformate, methylbromoformate, chlorodiphenyl methane and chlorotriphenyl methane.

8. The method according to claim 5, wherein said halogenated silicon compound is selected from trimethylchlorosilane, methyldichlorosilane, diethyl dichlorosilane, methyl trichlorosilane, ethyl trichlorosilane, trichlorosilane, dichlorotetramethyl disilane, dichlorotetramethyl disiloxane and silicon tetrachloride.

9. The method according to claim 1, wherein the component (c) has a chemical structure of the following general formula (19) or (20):



..... (19)



..... (20)

(wherein R^{25} is a hydrocarbon group having a carbon number of 1-20, and n is an integer of not less than 2).

10. The method according to claim 6, wherein the hydrocarbon group represented by R^6 in the formula (19) or (20) is methyl group, ethyl group, propyl group, n-butyl group, isobutyl group or t-butyl group.

11. The method according to claim 1, wherein the

component (d) is selected from the group consisting of trimethylaluminum, triethylaluminum, tri-n-propylaluminum, tri-isopropylaluminum, tri-n-butylaluminum, tri-isobutylaluminum, tripentylaluminum, trihexylaluminum, tricyclohexylaluminum, trioctylaluminum, diethylaluminum hydride, di-n-propylaluminum hydride, di-n-butylaluminum hydride, di-isobutylaluminum hydride, ethylaluminum dihydride, n-propylaluminum dihydride and isobutylaluminum dihydride.

12. The method according to claim 1, wherein the component (a) is used in an amount of 0.0001-1.0 mmol per 100 g of the conjugated diene compound and the catalyst has such a composition ratio that a molar ratio of component (a) to component (b) is 1:0.1-1:15, a molar ratio of component (a) to component (c) is 1:1-1:5000, a molar ratio of component (a) to component (d) is 1:1-1:500 and a molar ratio of component (c) to component (d) is 1:0.02-1:300.

13. The method according to claim 1, wherein the conjugated diene compound is selected from the group consisting of 1,3-butadiene, isoprene, 2,3-dimethyl-1,3-butadiene, 1,3-pentadiene, 1,3-hexadiene and cyclo 1,3-hexadiene.

14. The method according to claim 1, wherein an amount of each of the components (e)-(j) used to the component (a) is 0.01-200 as a molar ratio.

15. The method according to claim 1, wherein one of the components (e), (f) and (j) is used as a modifying agent.

16. The method according to claim 15, wherein the component (e) is selected from the group consisting of dibutyltin dichloride, dioctyltin dichloride, phenyltin trichloride, butyltin trichloride, octyltin trichloride, tin teterachloride, methyl dichlorosilane, methyl trichlorosilane and silicon tetrachloride.

17. The method according to claim 15, wherein the component (f) is diphentylmethane siisocyanate or polymeric type diphenylmethane diisocyanate.

18. The method according to claim 15, wherein the component (j) is selected from the group consisting of dioctyltin dilaurate, dioctyltin bisoctylmaleate, dioctyltin bisbenzylmaleate, dioctyltin bisethylmaleate and bisoctyltin maleate.

19. A conjugated diene polymer produced by the method of claim 1 and having a content of cis-1,4-bond of not less than 90% and a ratio of weight-average molecular weight to number-average molecular weight of not more than 4 as measured by a gel permeation chromatography.